

Training and Education for Green Construction in the U.S.

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Training and Education for Green Construction: Corporate Education Provision in the U.S.

Abstract

The construction industry is rapidly becoming convinced of the benefits to be gained by introducing green building design and planning technologies and strategies that affect green building operation and maintenance processes during the post-occupancy phase. Innovative green construction technologies are also receiving considerable attention as a way to ensure that projects will not only conserve local environmental conditions and natural resources but also help those living and working in and around the new building to maintain high quality and healthy lifestyles over the long-term. As a consequence, various private or public organizations are now employing these approaches and investing research and development funds to develop new green construction technologies. However, the importance of raising the awareness and consciousness of construction stakeholders about the benefits of green construction through training and education has not yet percolated through to all construction stakeholders in private or public organizations. Hence, this research was conducted to inventory the current state of practice for training and professional education in green construction in the U.S. and to develop a set of guidelines recommending appropriate content for green construction training and education programs. The study utilized a survey and on-site interviews with education and training experts from major nationwide construction companies, accompanied by a comprehensive literature review. Our findings revealed that only a limited number of professional construction companies offer and operate green construction training and education programs specifically designed for construction stakeholders participating in green construction projects as either in-house or outsourced training. The education and training experts interviewed indicated a number of topics that they consider essential for green construction training and education and suggested optimal operation strategies for delivering an effective green construction education and training curriculum for construction stakeholders in green construction projects. Two case studies shed additional light on how such programs can be provided.

Introduction

In the early 1990s, the energy crisis and environmental pollution began to receive serious attention from people around the globe, leading to demands that all sectors of society, including the construction industry, should implement working practices that minimize the negative impact of their activities on the environment. In particular, in the U.S. the building construction and operation phases of a building's life cycle consume 70 percent of the nation's electricity and 54 percent of all forms of energy, 12 percent of all freshwater, and 30 percent of the raw natural materials (Nielson et al. 2009; Elmer and Leigland 2014). Also, this stage produces 25 percent of the solid waste, including 45-65 percent of the waste going to landfills, is responsible for 31 percent of the mercury in solid waste, and generates 30 percent of the nation's greenhouse gas emissions in the world and the U.S. The industry document Build It Green (2007) notes that the construction process produces a great deal of avoidable and manageable construction waste on building construction sites.

As a result of this increased interest, the concept of green building is becoming widely accepted as a way to reduce environmental contamination and prevent natural resource depletion by applying green building strategies and technologies (Liu 2011). Simultaneously, the growing public awareness of the potential impact of the adoption of green building approaches has expanded to encompass not only green building training and education related to the planning and design phase, but also green construction training and education for the building stakeholders who will construct a building (Liu 2011; Li and He 2012; Tang 2013). In particular, Li and He (2012) insist that continuous, extensive, in-depth education and training is needed to raise the awareness of construction workers and support behaviors designed to achieve and sustain high quality of green construction, while Tang (2013) noted that the level of green awareness and consciousness within a construction company is a critical criterion to be borne in mind when selecting a cooperative partner to maximize the long-term benefits achieved by a green construction project, as shown in Table 1. The path that leads to high quality green construction starts with the individual construction workers' awareness of the importance of green construction and environmental protection and adopts a bottom-up mechanism known as the "green push" to root this awareness deeply in all the construction stakeholders. Liu (2011) also emphasized the importance of green construction education and training and reported that it is directly related to the level of awareness and consciousness of green construction. For instance, Liu (2011) demonstrated that a low level of green construction education and training is associated with an inadequate awareness and consciousness of the link between green construction and environmental protection.

Table 1. Factors that affect green construction awareness and consciousness from the green construction partners index system

Enterprise level	Green culture	An awareness of employees' environmental protection Green management organization Propagating green culture for all partners
	Green capability	Partners' green willingness Environmental management system (Ex. ISO ¹ 14000)
	Green index	Long-term green vision of development
Project level	Green economy	Environmental protection investment Eco yield
	Green craft	Entire lifecycle of green construction project and an awareness of the corresponding benefits The use of green craft and technology Emphasis on the market - research new green products Advanced environmentally friendly construction equipment

Synthesized from Liu (2011) and Tang (2013)

Based on the previous research, it is obviously necessary to develop and provide green construction education and training to green construction stakeholders if we hope to conserve the local environment and maintain the high quality of green construction site over the long term. This study therefore investigated the status of current U.S. green construction education and training programs, seeking to identify the core considerations for developing and operating better green construction education and training programs by conducting a comprehensive review of the relevant research literature as well as a series of interviews with education and training experts from major nationwide construction companies in the U.S.

The Status of U.S. Green Construction Education and Training

Numerous general contractors and institutions in the U.S. are now expressing their interest in green building projects, and their annual revenues from green building contracts are now being ranked and published by Engineering News Reports (ENR). A few general contractors who are on the list of Top 100 Green Contractors operate green construction education and training programs that have either been developed as an in-house training program or are delivered by third party education and training providers. Table 2 describes two general contractors who operate nationwide and provide green construction education and training programs for their employees.

¹ International Organization for Standardization

Table 2. Examples of general contractors who operate a green construction education and training program²

Company	Headquarters location	Green building contractors ranking (ENR, 2015)
Turner Corp.	New York, NY	1
McCarthy Holdings Inc.	St. Louis, MO	27

In general, the purpose of the green construction education and training programs operated by the major general contractors in the U.S. is to provide world-class sustainability services to their current and future clients and to stay ahead of their construction industry competitors by cultivating in-house expertise in green construction, with internal experts who are capable of taking advantage of new opportunities and employees associated with green building projects who are equipped to exceed expectations in this area. The general contractors in Table 2 are both interested in developing or operating green construction education and training programs to help them to achieve green construction sites for their green building projects. Therefore, this research describes these current in-house green construction education and training programs in detail and the required contents and the priority of green construction education and training program to develop the new program or improve the current program for nationwide-level-general contractors in the U.S.

Research methodologies: Survey, Interview, and Literature Review

This research was conducted via online surveys completed by the individuals in charge of the aspects of sustainable health and safety disciplines related to green construction in the general contractors' employee education programs at the nationwide companies in the U.S. Several additional online and face-to-face interviews with survey participants responsible for the green construction education and training in each general contractor were also conducted for this study. Eight experts from an engineer level to a vice president level were participated in this survey and interview for this research, and they could chose multiple answers to certain questions out of 19 questions specifically designed to elicit the information needed to satisfy the objectives of this study. The information gathered enabled us to identify the specific characteristics of the curriculum content that they considered most important and the program dimensions and approaches to program operation and management covered in each program, making it possible to discern the essential components required for developing and operating a new green construction education and training program.

U.S. Green Construction Education and Training Program by Private General Contractors McCarthy Building Company

The McCarthy Building Company has invested in the development of their own in-house continuing education program, McCarthy Build U Learning and Development Program, which includes the 'McCarthy Green Curriculum', for their employees. The McCarthy Green Curriculum is registered as a qualifying LEED online continuing education course for their

² http://www.enr.com/toplists/2015_Top_100_Green_Building_Contractors (January 10, 2016)

employees. This customized in-house training program covers the areas of design, construction, and operation for a green building project, including topics such as the following:

- Project Site Factors
- Water Management
- Project Systems and Energy Impacts
- Acquisition, Installation, and Management of Project Materials
- Improvements to the Indoor Environment
- Stakeholder Involvement in Innovation
- Project Surroundings and Public Outreach

The company aims to implement up-to-date innovative solutions for green construction throughout the company via their national Green TeamWork Group, which are made up of staffs who hold various positions in each regional office and have different areas of expertise (Table 3). This diverse group of members enables the Green TeamWork Group to develop and provide very specific and necessary study areas tailored to the company’s actual green building construction projects from the standpoint of the McCarthy Building Company’s history and culture. Their roles are to optimize the composition and content of the McCarthy Green Curriculum through open and wide-ranging discussions.

Table 3. Members of Green TeamWork Groups for the McCarthy Green Curriculum

Green Team Work Groups	Position	Region
	Vice President Quality and Sustainability	Headquarters
	Executive Vice President Operations	Southwest region
	Vice President Operations	Southern California region
	Vice President Operations	Southwest region
	Vice President Operations	Texas region
	Vice President Preconstruction	Southwest region
	Project Manager	Southwest region
	Division Controller	Central region
	Business Developer	Federal region
	National Public Relations Manager	Federal region
Estimator	Central region	

The content of the McCarthy Green Curriculum displays several characteristics of company-wide training programs that are commonly found among the seven types of inventory of current education and training programs run by construction companies (Table 4). Based on the dimensions of the characteristics of the McCarthy Green Curriculum, the Green TeamWork Groups have developed 29 online courses for their employees, most of which are directly related to green construction processes or green construction technologies and strategies for the construction phase. The courses in the McCarthy Green Curriculum are listed in Table 5.

Table 4. The Dimension of the Characteristics of the McCarthy Green Curriculum

Dimension	Description
Format	Unstructured, based on self-study
Delivery	In-house, with in-house resources
Role/Discipline	A mix of disciplines
Specificity	Generalized coverage of all operations or projects Specification and uniqueness for the requirements or constraints of individual projects
Abstraction/Practicality	Explanation of the reasons for approaches, processes, and activities
Novelty	Introduction of new approaches, concepts, and ideas A refresher or maintenance course
Assessment	Multiple ways to conduct assessments: Simple attendance, quiz and examination.

(Pearce and Suh 2013; Suh et al. 2014)

Table 5. The 29 Courses offered Online in the McCarthy Green Curriculum

No.	Course Title	No.	Course Title
1	Living Building Challenge	16	On-Site Renewable Energy
2	Commissioning	17	Commissioning
3	Green Roof Construction	18	Design Management
4	Rapidly Renewable Materials	19	System Controllability
5	Water Efficient Landscaping	20	Low Emitting Materials
6	Construction IAQ Management	21	Ventilation
7	Improving Manpower and Materials Flow	22	Energy Performance Management (EPM) – Modeling through Operation
8	Construction IAQ Management	23	BIM and Sustainable Design
9	Construction Waste Management	24	Brownfield Redevelopment
10	Stormwater Management	25	Sweet Spot
11	Plumbing Fixtures	26	Light Pollution Reduction
12	Green Roof Preconstruction	27	Natural Ventilation
13	Green Trades	28	Building Orientation
14	Opportunities to Achieve Energy Reduction	29	Construction Activity Pollution Prevention
15	Owner Commitment to Sustainability		

McCarthy consider construction IAQ management to be fairly important because they devote two courses, at core and advanced levels, to managing IAQ during the construction process in order to deal with potential health issues on their jobsites. In addition, other courses such as Construction Waste Management, Commissioning for the Construction Phase, Construction Activity Pollution Prevention, and Light Pollution Reduction, among others, are directly related to the green construction process and can have a tremendous impact on green building projects. The contents of all the courses in the McCarthy Green Curriculum are updated regularly whenever a new and improved solution becomes available. Moreover, actual green building project cases that apply or use new innovative green construction technologies or strategies are reflected in the content of the McCarthy Green Curriculum as an in-house best practice. As a result, the curriculum is closely linked to the company's green building projects.

Turner Corporation

As part of Turner Corporation's commitment to green building and sustainability, the company operates education and training programs for their employees to raise their awareness of these issues. The company has established the following set of Turner Sustainable Policies to support the implementation of education and training for green building and sustainability.

- *Train Turner's people:* Turner provides green building training for all company employees to help them to earn LEED GA or LEED AP certification.
- *Reduce and recycle construction waste:* More than 1.5 million tons of construction waste have been either reduced or recycled on the company's worksites instead of ending up in landfills since the policies were introduced in 2005.
- *Reduce greenhouse gas emissions:* The company achieved a five percent decrease in corporate greenhouse gas emissions between 2006 and 2011.
- *Seek LEED certification for Turner offices:* 16 Turner offices, comprising about 400,000 square feet, have achieved various levels of LEED certification.
- *Green field offices and activities:* A set of sustainability standards, including a site specific indoor air quality plan, a construction waste management plan, and a construction activity pollution prevention plan, has been established for each of the company's offices and jobsites.
- *Report environmental performance:* Turner publishes regular reports about their environmental performance.
- *Research and share green building information:* Turner supports the development of new technologies and strategies for green building, and implements these technologies and strategies, either through further research, a pilot project, or as a case study.
- *Promote a culture of safety:* Turner focuses on their employees' safety and health in the workplace. The principle of Building Living Injury Free Everyday (L.I.F.E) has been adopted company-wide to promote Turner's culture of safety, not only for their employees, but also their contractors, clients, and the surrounding community.

In particular, in 2004 Turner's CEO, Mr. Thomas Leppert, initiated a formal commitment, "Turner Green", in support of the company's sustainable construction and business practices as part of the company's commitment to leadership in the U.S. construction industry. According to the formal commitment, Turner operates two different education and training programs, TurnerTalk and Turner University, to support green building projects, jobsite training, and company-wide training. Turner's green building projects are also based on the TurnerTalk system, which can help Turner jobsites and departments build and manage their projects over the internet by accessing this powerful and full-featured Prolog application. Given its extensive use in the Turner Knowledge Network, Prolog training is therefore essential for all project participants before starting a green building project. The training process is shown in Figure 1, and the key features of TurnerTalk are presented in Table 6.

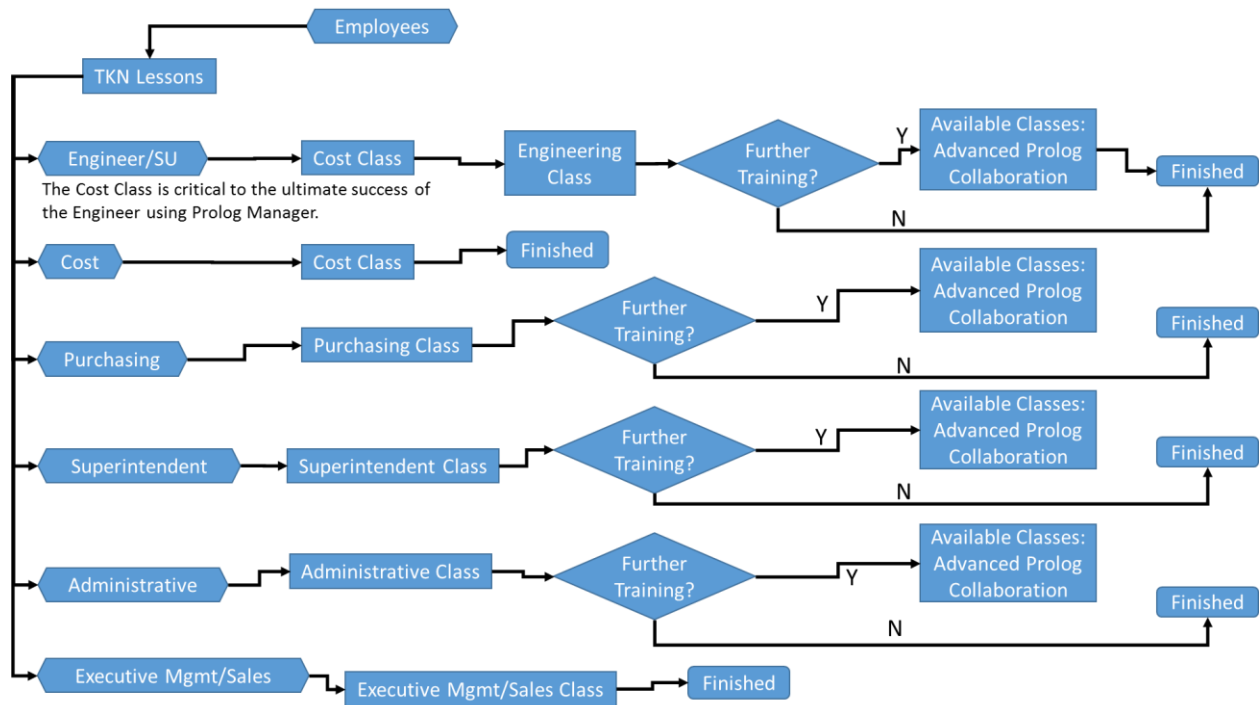


Figure 1. Prolog Training Process Matrix³

Table 6. Key Features of TurnerTalk⁴

Multi-Site, Multi-Project Control	User Friendly Project News
Personal Action Item Management	Scheduling and Resource management
Online Project Collaboration	Project Document Management
Field Administration	Cost Control
Purchasing	Extensive Reporting
Powerful security for each feature, field, report, file, etc.	

The information provided by TurnerTalk is supplemented by various courses related to the construction process that are provided by Turner University via a web-based online training program in addition to more general courses such as business skills, finance, and technology. Some green construction courses are already available through Turner University, with new courses constantly being prepared to meet the company's specific needs. Table 7 provides a list of the green construction courses already provided by Turner University.

³ <https://aecms.com/mk/images/AECMS%20training%20flow%20chart.pdf> (Access on Jan. 1, 2014)

⁴ <https://aecms.com/MK/about/features.asp> (access on Jan. 1, 2014)

Table 7. Current and prospective green construction courses offered by Turner University⁵

	Course	Description
Currently available	Mold Awareness and Moisture Control	<ul style="list-style-type: none"> • The risk of litigation and financial risk • The issue of mold in construction and possible solutions for mitigating the risk <ul style="list-style-type: none"> - Creating an awareness of risk management - Identifying effective ways to control mold
	MEP Fundamentals: Startup and Turnover	<ul style="list-style-type: none"> • The purpose and benefits of Mechanical, Electrical, and Plumbing (MEP) systems startup and turnover • Explanation of the process for using MEP systems effectively during startup and turnover <ul style="list-style-type: none"> - Explaining MEP startup and turnover and their importance - Showing the MEP startup and turnover process - Explaining the steps of the planning phase, the startup phase, and the turnover phase - Managing the process for a simple MEP installation
	Environmental Risk Management	<ul style="list-style-type: none"> • An awareness of the risks and liabilities associated with environmental hazards and how to manage these risks • Objectives: <ul style="list-style-type: none"> - Recognizing environmental hazards associated with new construction and renovation projects - Describing the components of the Phase I and II environmental site assessments - Identifying actions to take during all phases of a project to minimize the risks associated with environmental hazards - Listing knowledge resources available
	OSHA 10-Hr Course	<ul style="list-style-type: none"> • An awareness of construction-related safety and health issues • Outreach Training Program courses as an orientation to occupational safety and health for workers • 12 individual lessons and associated lesson assessments • Overall 20 questions assessment • Student course evaluation
	OSHA 30-Hr Course	<ul style="list-style-type: none"> • An awareness of construction-related safety and health issues • Understanding of OSHA regulations • Outreach Training Program courses as an orientation to support occupational safety and health for workers • 28 individual lessons and associated lesson assessments • Overall 20 questions assessment • Student course evaluation
	Stormwater Subcontractor Short Course	<ul style="list-style-type: none"> • Overall basic stormwater issues • Turner's employees as well as their sub-contractors

⁵ http://www.turneruniversity.com/turner_u_course_catalog/courselist.aspx# (access on Jan. 1, 2014)

Preparing	USGBC LEED: Construction Phase Essentials - Construction Waste Management	<ul style="list-style-type: none"> • The utility of construction professional activities • The implementation of indoor air quality during the construction phase. • Objectives: <ul style="list-style-type: none"> - Stating the USGBC requirements during construction phase - Describing waste recycling options as they pertain to Construction Waste Management - Explaining the importance of contract language specific to waste management - Identifying elements of a Construction Waste Management plan - Explaining methods for training and monitoring the workforce for Construction Waste Management - Describing methods and procedures for tracking waste - Explaining the LEED submission documentation and process
	USGBC LEED: Construction Phase Essentials - Credit Documentation for Construction Managers and General Contractors	<ul style="list-style-type: none"> • The assistance of construction professional activities • The implementation of indoor air quality during pre-planning, construction and pre-occupancy phases of construction including construction phase. • Objectives <ul style="list-style-type: none"> - Defining credits for energy, construction, and design - Describing the items/steps in the LEED documentation checklist - Describing the relevant requirements and the submission documentation of sub-contractors for LEED credits - Describing the various types of information for LEED documentation
	USGBC LEED - Construction Phase Essentials - Indoor Air Quality Administration	<ul style="list-style-type: none"> • The utility of construction professional activities • The implementation of indoor air quality during pre-planning, construction and pre-occupancy phases of construction including construction phase. • Objectives: <ul style="list-style-type: none"> - Understanding and preparing an appropriate construction phase indoor air quality - Implementing the plan at all phases of construction during delivery, storage and installation, housekeeping and scheduling considerations - Pre-occupancy procedures and flush out • Preparing real time documentation for each phase
	USGBC LEED: Construction Phase Essentials - Credit Documentation for Subcontractors	<ul style="list-style-type: none"> • LEED overview, LEED process, Roles and responsibilities of general contractors, construction manager, and sub-contractors • Documentation guideline • Objectives: <ul style="list-style-type: none"> - Explaining LEED process - Describing the roles and responsibilities of the general contractor/construction manager(construction phase) - Describing the roles and responsibilities of sub-contractors in submitting documentation during the construction phase - Explaining the formatting and timing guidelines and the requirements for reporting material and installed costs

Essential Topics in Green Construction Education and Training Curriculum

The survey conducted for this research found that the topics considered essential for a green construction education and training curriculum for any company seeking to improve the quality of an existing program or develop a new, high quality, green construction education and training program. The participants ranked the importance of green construction education and training very highly, deeming it a key aspect of green construction, and the survey results also supported the relative importance of various aspects of green construction from the general contractor's standpoint, as shown in Figure 2 below.

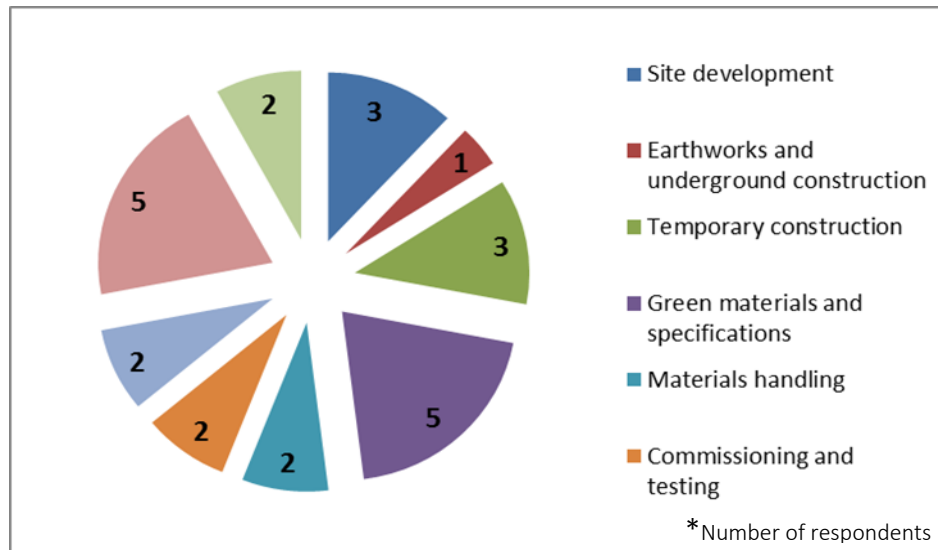


Figure 2. Important considerations for the implementation of green construction practices

The survey respondents emphasized that the company's green philosophy must be an integral part of the green construction education and training curriculum from the outset, as an awareness of the company's green philosophy is fundamental if the company is to change traditional work practices and enhance the performance of its employees working on green building projects. In addition, the survey participants considered it especially helpful to concentrate on the company's major green construction factors related to this green philosophy during the green construction phase, as shown in Figure 3.

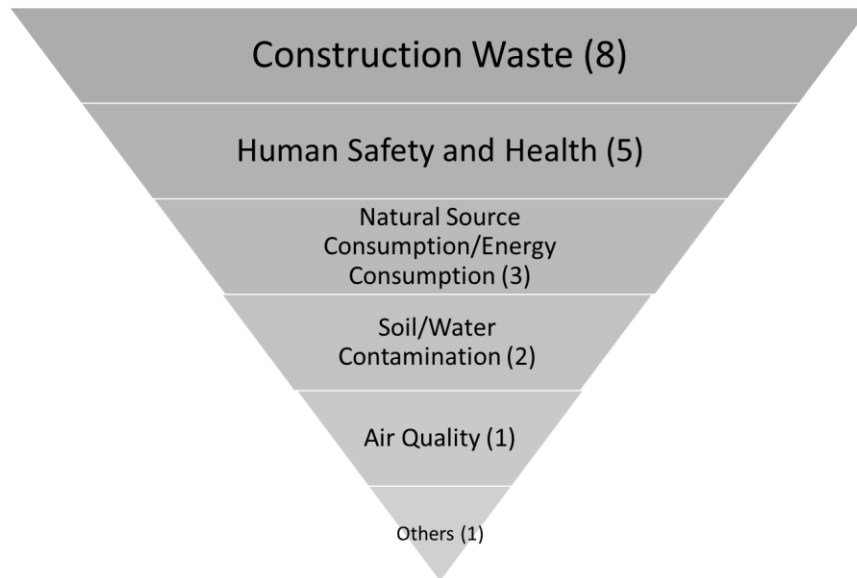


Figure 3. Key Green Construction Factors for Establishing Company’s Green Philosophy

Based on the green philosophy, the curriculum for green construction education and training can vary considerably to match each company’s precise requirements. The core study areas in a green construction education and training curriculum can also be different from each company, once again depending on the company’s green philosophy. However, there was a general consensus among the study participants on a number of essential study areas related to building or providing a green construction education and training curriculum for the target audience. The topics in Table 7 could be satisfied with the fundamental requirement of the construction phases fell into three main categories such as green procurement, jobsite operation and green construction management plans, and project surroundings and public outreach in advanced.

Table 7. Essential Topics for a Green Construction Education and Training Curriculum

ISO 14001 Registration	Operational Plans for Project Selected Environmental Significant Aspects
Regulatory Compliance	LEED Accreditation Curriculum
Site Development and Protection	Green Materials and Specifications
Materials Handling	Commissioning, Testing , and Balancing
Green Procurement	Jobsite Management Plan
Green Management Plans	Project Surrounding and Public Outreach
Company’s Philosophy	Carbon data collection

Conclusion

As shown by the case studies, green construction education and training curricula commonly focus on the following construction processes and may include LEED assessment topics:

- *Construction site*: Erosion and sediment control, no invasive plants, overall irrigation demand reduction, etc.
- *Stormwater*: Permeable lot, etc.

- *Water reuse*: Rainwater harvesting systems, innovative technologies, etc.
- *Indoor water use*: High-efficiency fixtures, innovative technologies, etc.
- *Materials and resources*: Local material use, certified materials and resources, etc.
- *Construction waste*: Construction waste management, construction waste management plan, etc.
- *Indoor air quality*: Construction indoor air quality plan, indoor contaminant control, etc.

Based on these essential topics and key points related to green construction education and training operations, the survey participants recommended several required curriculum topics and delivery timings that should be considered when developing a green construction education and training program for a private construction company. An important aspect of developing and operating any green construction education and training program is to aim to not only improve the company's green construction capacity and raise employees' awareness and consciousness of the important benefits to be gained through green construction, but also to promote the use of more effective and efficient green construction activities on the job site, thus contributing to the successful completion of the green construction project. Given the importance of green construction education and training, the program offered should be customizable and open to continuing revision and updating of the educational content and delivery timings in order to match the trainees' conditions and situations appropriately and thus allow both them and the company to gain the maximum benefit from implementing a green construction education and training program. In a future research, the specific contents of green construction education and training and the detail operation methods should be investigated for achieving a true green construction project.

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References

- [1]. Build It Green. (2007). New Home Construction Green Building Guidelines, Build It Green-Smart Solution From The Ground Up.
- [2]. Elmer, V. and Leigland, A. (2014). Infrastructure Planning And Finance: A Smart And Sustainable Guide For Local Practitioners, Routledge, New York, NY
- [3]. Li, S. and He, B. (2012). On Measures to Promote Green Construction, Management and Engineering, 09(2012), 103-106.
- [4]. Liu, X. (2011). Green Construction Management System for Construction Project, International Conference on E-Business and E-Government, Shanghai, China, May 6-8, 2011.
- [5]. Nielson, C., Wolfe, C. B., and Connie, D. (2009). Green Building Guide-Design Techniques, Construction Practices and Materials for Affordable Housing, Rural Community Assistance Corporation.
- [6]. Pearce A. R. & Suh, M. (2013). Green Construction Technologies and Strategies in the U.S. Blacksburg, VA: Sustainable Facilities & Infrastructure Lab, Myers-Lawson School of Construction, Virginia Tech.

- [7]. Suh, M, Pearce, A. R., and Jeon, M. (2014), Green Construction: An Inventory of Training and Education Approaches in the United States, the ASC 50th International Conference, Washington D.C. March 28-28.
- [8]. Tang, H. (2013). Green Construction Partner Selection, Applied Mechanics and Materials, 260-261(2013), 290-295.